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Bill Chen joined United Defense on December 16, 1994. He is currently Vice President, Division Engineering, Armament Systems Division, Minneapolis, Minnesota. Bill previously served successively as Vice President and Program Manager for the Crusader program, and as Vice President, Army Programs.

Before joining United Defense, Bill was a vice president for Nichols Research Corporation in Vienna, Virginia. Bill retired from the United States Army in September 1983 as a Major General. Key assignments included: Program Executive Officer for Missile Defense -- responsible for the Army's theater and national missile defense programs, and Commanding General, U.S. Army Missile Command --responsible for the development, procurement, support and international sales of Army missiles. He has had high level staff assignments in the Office of the Chief of Staff, Army and the Office of the Secretary of the Army for Research, Development and Acquisition. He has had experience in the operational aspects, combat developments, program management, acquisition management, and logistics support of Army weapons systems. He has served as an Army program manager for two major defense programs and has commanded a battalion. His overseas assignments have been in Korea, Vietnam, Thailand, and Laos.

Bill received a B.S.E. in Engineering Mathematics and M.S.E. in Aeronautical and Astronautical Engineering, both from the University of Michigan. He has an M.B.A. from Auburn University. He is also a graduate of the Defense Systems Management College and the Industrial College of the Armed Forces.

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Armaments for Full Spectrum Warfare: Technology Enablers for the Future (Lethality Focus)

Bill Chen

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Purpose

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- To Provide a Perspective on Armaments for the Future
  - Beyond traditional
  - With focus on technology enablers
- To Highlight the Importance of Pulse Power to the Future Armaments
  - It is a critical technology enabler
  - It is applicable to both electric armaments and directed energy weapons

Outline

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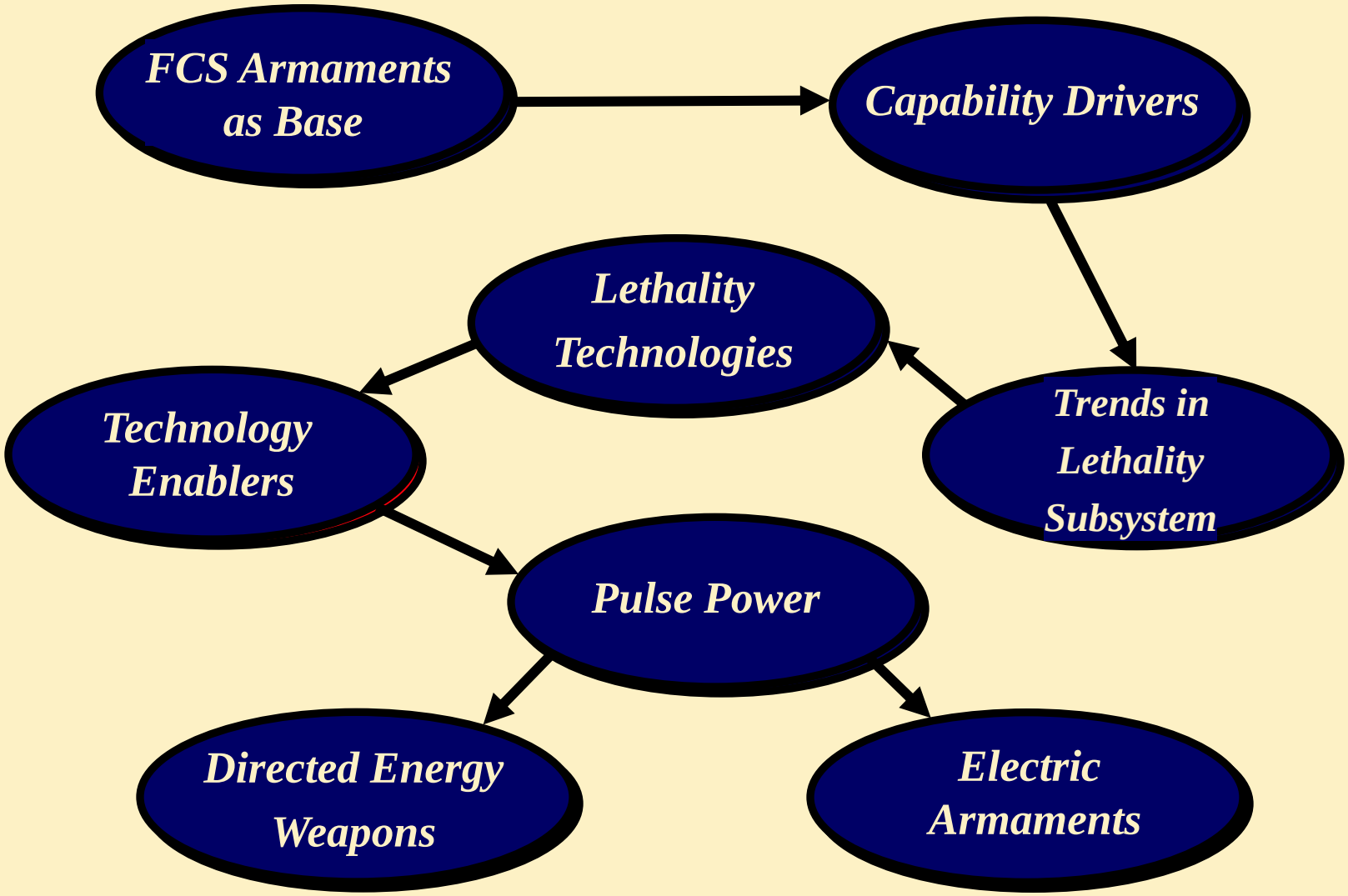

FCS Armaments as A Base

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<u>Armament System</u>

- Mobility Subsystem
  - Traction drives
  - Active suspension
  - Hybrid electric drive
- Lethality Subsystem
  - Lightweight cannons and guns
  - Conventional propellants
  - New precision munitions with increased lethality
- C4ISR Subsystem
  - Network centric
- Survivability Subsystem
  - Enhanced armor and composite materials
  - Active protection

Capability Drivers for Future Armament Systems for Full Spectrum Warfare

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- Lighter
- More Deployable
- More Survivable – Reduced Footprint
- Must Continue to Provide “Specialty” Lethality Needs, e.g., Smoke, Illumination, Bunker Busting, Antipersonnel, etc.
- More Flexible Response -- Goes Beyond “Traditional” Firepower
  - Innovative lethality mechanisms
  - Directed energy
  - Electric armaments
  - Precision ignition
  - Non-lethal capabilities
- More Supportable
  - Significantly improved reliability and availability
  - Maintainable
  - Automated resupply

Trends in Lethality Subsystems

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- Increased Lethality
  - Improved warhead effectiveness
  - Shorter time of flight (direct fire)
  - Novel penetrators
  - Directional fragmentation
  - Alternative energy delivery systems
  - Counter-countermeasures
- More Precision
  - Enhanced sensors
  - Reduced sensor-shooter links
  - Better targeting
  - Error correcting rounds
  - Counter-countermeasures

Trends in Lethality Subsystems (cont.)

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- Tunable Effects
  - Covers gamut of non-lethal to lethal
  - Multi-role capability
- Significant Reduction in Logistics
  - Efficient packaging
  - Elimination of propellant and associated handling
  - Deep Magazines “No Bullets”
  - Smaller, more intelligent, highly reliable subsystem components
- Synergy of Applied Technology
  - Force protection enhancement via cooperative engagement
  - Growth from hybrid-electric to fully electric-based system
  - Dual use of components within mobility subsystem

Technology Enablers

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- Advanced Materials
  - Better steels
  - High strength/high modulus composites
  - Erosion resistant coatings
  - Memory alloys
- Application of MEMS Technology
  - Cost effective, high g-hardened ammunition sensors
  - Sensors for intelligent diagnostics and prognostics
- Advanced Energetics and Propellants
  - Order of magnitude increase in energetics' energy density
  - More energetic, low vulnerability, low flame temperature environmentally-friendly "green" propellants
- Pulse Power
  - Common system solution for electric armaments and directed energy weapons

Pulse Power is a Critical Enabler for Future Full Spectrum Warfare Armaments

Armament System Architecture for Full Spectrum Warfare

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Lethality

- ETC gun
- EM gun
- Solid State Laser
- High Power Microwave

Pulse Power System

Survivability

- Active defense
- Signature management
- NBC/ECS
- EM armor
- Countermeasures

C4ISR

- Sensors
- Target identification & allocation
- Battlefield Management

POWER DISTRIBUTION

Integrated Hybrid-Electric Power

- Engine
- Generator
- Fuel Cell

- Flywheel
- Ultra-capacitor
- Batteries

Power Generation	*Energy Storage*

Mobility

- Traction motors
- Power converters
- Cooling systems
- Active suspension

Pulse Power: A Definition

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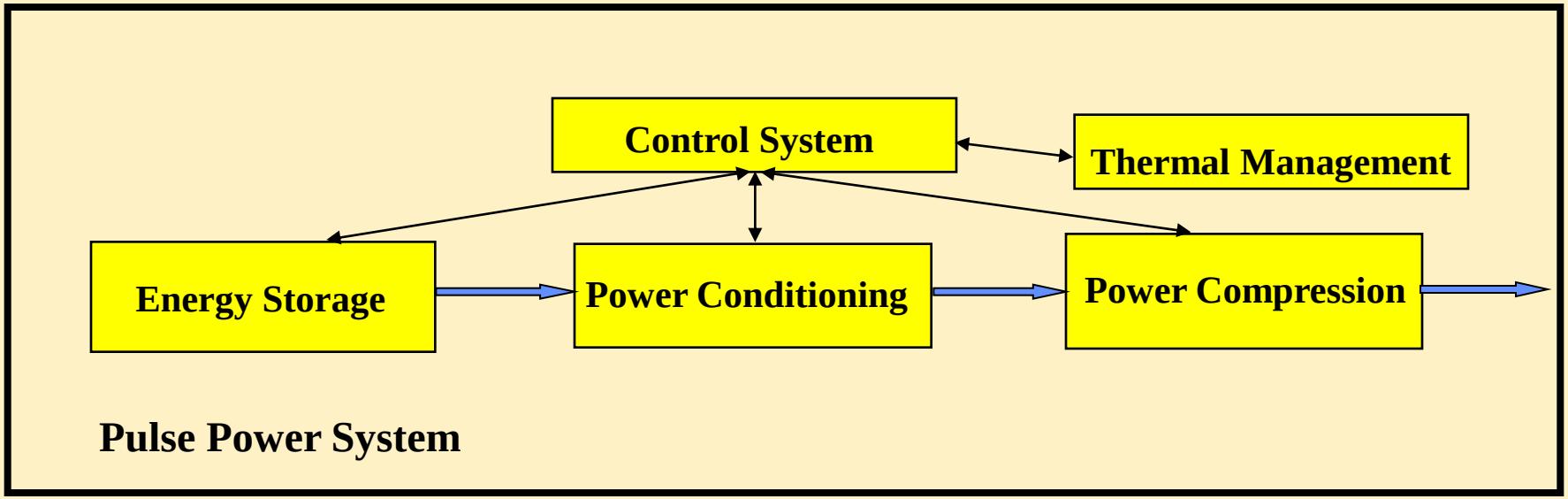
- A Pulse Power System includes:
  - Energy storage
  - Power conditioning
  - Power compression
  - Control system
  - Thermal Management



Pulse Power for Multiple Applications

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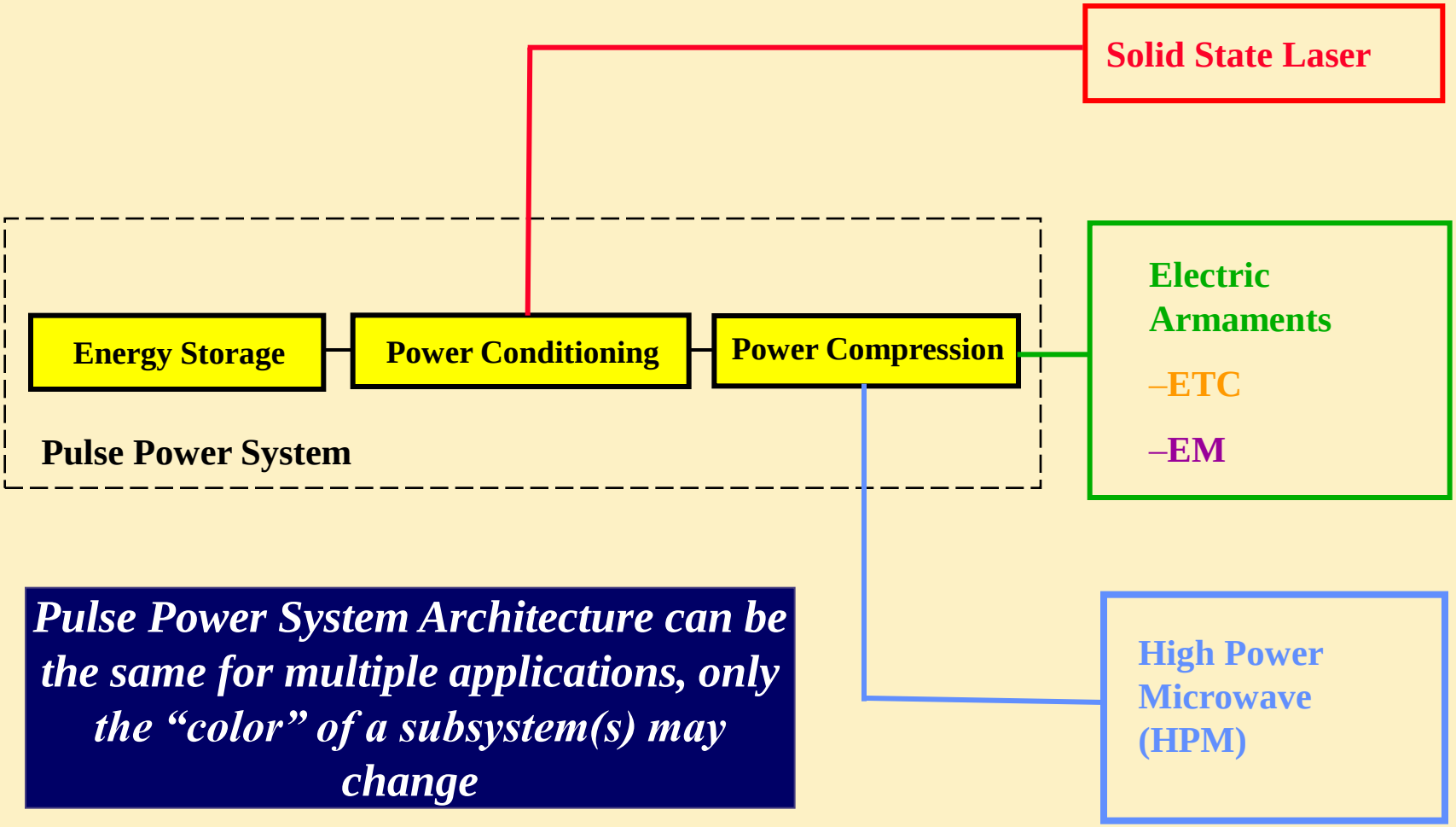

Pulse Power System Architecture can be the same for multiple applications, only the "color" of a subsystem(s) may change

Electric Armaments

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- Electrothermal Chemical (ETC)
  - Significant enhancement in accuracy
  - Maximizes performance across temperatures
  - 35% increase in muzzle energy (with high energy propellants)
    - "140mm performance from a 120mm cannon"
  - Small power supply required
- Electromagnetic (EM)
  - Hypervelocity rounds enables defeat of complex armors that are not vulnerable to conventional rounds cannot
  - EM round smaller penetrators than conventional round
  - No propellant
  - Significant reduction in logistics tail
  - Power supplies are large, and need further development

Directed Energy Weapons

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- Lasers
  - Speed of light capability
  - Continuum of selectable energy levels provides non-lethal to lethal effects
  - “Magazine” limited by chemical fuel capacity or electrical production/storage capability
  - Potential EMP effects may be possible
- High Power Microwaves
  - Non-lethal to lethal effects
  - Continuum of selectable energy levels provides non-lethal to lethal effects.
  - Can be fielded as tactical weapon sooner than lasers
  - EMI effects on friendly electrical equipment
  - “Magazine” limited by power production/storage capability
- Particle Beams
  - Many technical issues to solve
  - Could have large EMP effects on targets

Concluding Remarks

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- **Future Lethality Subsystems Will Yield Substantial Increases in Capability**
  - **Increased Precision**
  - **Tunable effects from non-lethal to lethal**
  - **Awesome firepower potential**
  - **Significant reduction in logistics**
- **The Outlook for the Future of Armaments is Extremely Positive as We Move Away from Traditional Armament Technologies and Turn Toward to Alternative Energy Delivery Means…but:**
  - **Tech Base must focus on requirement to achieve pulse power capability and support FCS technology insertion for directed energy and electric armaments**

Pulse Power is a Critical Enabler for the Future of Armaments in Full Spectrum Warfare